the proof supplied, that, under conditions very favourable to rapid and complete desiccation, such as free exposure to air and sun, bacteria may be destroyed in a comparatively short time, not less, however, than from two to four days being needed even in this climate in summer, and even longer, unless the weather be actually hot.

Since writing this paper I find from a passage in a letter contained in *Nature* (vol. III., p. 247), that Dr. Bastian had been led to ascribe to the actinic rays of the sun an important influence in promoting the spontaneous generation of organisms in organic infusions. Though that notion may be considered as fairly set aside by Professor Tyndall's experiments, recorded in the *Philosophical Transactions* (part I., 1877), and again in his *Essays on the Floating Matter of the Air* (p. 231), the interesting fact remains that, at different times, both a favouring and an inimical action on the development of these minute organisms should have been ascribed to the sun's rays, when in reality they appear to have little, if any, appreciable direct influence in either direction.

Art. VIII.—*Remarks on Railway and Marine Signals, and on the Necessity of Accurate Testing of the Sight of Signal and Look-out Men by Land and Sea.*

By James T. Rudall, F.R.C.S.

[Read 8th June, 1882.]

The great increase of travelling in recent years, the large numbers of ocean-going and other steamships, the frequency of railway trains running over the same lines, and the numerous intersections of these, have become attended by dangers of which some cannot be wholly eliminated; and others, though avoidable, are only now beginning to receive attention.

If one remembers that between New York and Liverpool nearly thirty large steamship companies have their vessels

constantly running over almost the same track of ocean at a speed often of sixteen or eighteen knots an hour; or if one observes the succession of trains at a large railway station like the Victoria, in London, one is likely not to underrate the necessity of increasing vigilance and perfect physical capability on the part of the signallers and look-out men and the drivers of trains. Very little reflection suggests the necessity of using a code of signals suited as regards size and colour to the optical capacities of the normal eye, as these have been determined by scientific examination. Of course this has already been partly attended to long ago in a rough way, but by no means with the accuracy which the subject now both permits and demands. Almost equally apparent is it that the signals should be, at least in the case of ocean steamers and railway lines of coterminous countries, not national but international.

Another at least equally important condition requisite to ensure safety in travelling is visual competency on the part of all those who are engaged in signalling or in looking out for signals.

The essential requirements therefore are :—

1. A series of signals for sea, to be agreed upon and accepted by all maritime nations; and, further, an uniformity as to size, colour, and signification of land (railway) signals.

2. That these signals should be in relation with the visual acuity and colour perception of the normal human eye.

3. That no signallers or observers should be employed who do not come up to a certain fixed standard of visual acuity, refraction, and colour sense.

In regard to the first of these requirements, the necessity of a commission of delegates from the principal maritime Governments was strongly urged by the International Medical Congress of 1881, in order to secure uniformity in size, colour, and disposition of signal lights. Such a commission would at the same time ensure the conditions required under the second heading. But there should be no delay in carrying out the third requirement. This is absolutely essential to the safety of life of the travelling population.

It might be thought that nothing can be easier than to decide, with but little trouble or method, whether a person has good sight and good perception of colours. In a very small percentage of those who would present themselves for examination this question might, perhaps, be at once decided

in the negative; but in a relatively large proportion the incapacity would be detected only by a detailed and systematic examination.

It is, of course, well known that one condition essential to distinct vision is that an image of the object looked at should be formed on the retina.

As regards refraction, it is now generally accepted that the dioptric media in the normal eye accurately focus parallel rays on the percipient layer of the retina; consequently neither divergent nor convergent rays can be brought to a focus on that percipient layer without some alteration.

For divergent rays this alteration is effected by an increased convexity of the crystalline lens, produced through the agency of the ciliary muscle.

Hooke* investigated the angular distance required to observe two fixed stars separately, and he found that among a hundred persons scarcely one was in a position to distinguish the two stars when the apparent distance is less than 60″. The correctness of this observation of Hooke has been confirmed in different ways by modern investigators. Professor Snellen, of Utrecht, some years ago devised a series of black letters on a white ground, which are easily read in good light by the normal eye at such a distance that the whole letter is seen under an angle of 5′, but the openings in the letters under an angle of 1′. These test types have come into general use by those concerned in the management of optical defects of the eye. It is necessary that the results of an examination by the types should be further supplemented by determination of the refraction, because it is possible for a myopic,† or short-sighted person, sometimes to read No. 20 Sneller at 20 feet by partly closing the eyelids, so as to diminish the circles of dispersion on the retina (and, perhaps, by, at the same time, slightly flattening the eye), and, on the other hand, a hypermetropic‡ person, with good accommodation, may also read the same letters—viz., No. 20 at 20 feet.

There is yet another anomaly of refraction—viz., astigmatism, in which, owing to the curvatures of the dioptric system being unequal in the different meridians, no true

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**Posthumous Works* (1705), quoted by Professor Donders.

†In whom parallel rays are brought to a focus in front of the retina.

‡In whom parallel rays, if continued, would come to a focus only behind the retina.

focus is formed. If the vertical meridian has a shorter radius of curvature than the horizontal, a point of light in the focus of the latter will not be seen as a point, but as approaching the form of a horizontal line, and *vice versa*. An eye may be normal or hypermetropic in one meridian and myopic in another. So, besides deciphering the test types, the eye must also be proved emmetropic—*i.e.*, to possess normal refraction.

Of course if any of these anomalies of refraction were present in a high degree, the individual would not be able to read the large test types at the required distance, yet a dangerous amount of ametropia might remain concealed it special attention were not also directed to the state of the refraction. The visual field must also be complete; there are cases in which, with great contraction of the field, the sharpness of sight remains good in the central parts.

We now come to the colour perception, which has of late years attracted so much attention. Absolute colour-blindness is a very rare condition; but in the male sex of the white races, diminished colour sense would appear to be of quite unexpected frequency. Thus, according to Mr. George Lawson, Professor Donders, of Utrecht, found amongst 2300 railroad *employés* that 152, or 6·60 per cent., were colour-blind. Professor Holmgren, of Sweden, found amongst 32,165 males that 1019, or 3·25 per cent., were colour-blind. Dr. Cohn found amongst 2429 schoolboys of Breslau 95, or 4 per cent., colour-blind. Dr. Magnus found amongst 3273 school boys of Breslau 3·5 per cent. colour-blind. Dr. Joy Jeffries, of Boston, found amongst 10,387 that 431, or 4·149 per cent., were colour-blind. In the female sex colour-blindness seems rare. It is known that for ordinary vision that part of the retina including the macula lutea and its immediate neighbourhood is the most sensitive, and that in proportion as images are formed on the more peripheral parts the impression conveyed to the sensorium is less exact and intense. From careful examinations it has been found that blue is distinguished over a larger portion of the visual field than red, and red over a larger part than green. It appears that within the limit of the visual field in the normal eye there is a zone of about 10° in which pigment colours are not recognised. What seems at first surprising is that many colour-blind persons (I use the term in the sense before ascribed to it) do recognise and name correctly the principal colours. "Thus," says Professor Pole,

"a soldier's red coat or a stick of red sealing-wax conveys to me a very positive sensation of colour, by which I am able to identify in a great number of instances bodies of this hue. If, therefore, the investigation of any experiences ended here, there would be no reason to consider me blind to red. But when I examine more closely what I do see, I am obliged to come to the conclusion that the sensation I perceive is not one that I can identify separately, but is simply a modification of one of my other sensations. It is, in fact, a yellow shaded with black or gray, a darkened yellow, or what I may call yellow-brown. I find that all the most common hues of red correspond to this description; and in proportion as they are more scarlet or more tending towards orange, the yellow I see is more vivid. The explanation, I suppose, is that none of such reds are pure—they are combinations of red with yellow, so that I see the yellow element of the combination, while the true red element of the combination is invisible to me as a colour, and acts only as a darkening shade."

Dr. Wolfe, referring to colour-blindness, says:—"It may well be asked, how is it possible for a colour-blind engine-driver, for instance, to perform his duty for any length of time without exposing his deficiency? But the explanation given by Holmgren is simple when we come to remember that a colour-blind person may come to distinguish between red, green, and white lanterns or flags, and even learn to call them by their right names, whilst all the time it is not colour which he sees; he only differentiates by the degree of intensity of light." "In short, the colour-blind person supplements his defective vision of colour by all secondary aids. He trains himself to notice differences which escape most other eyes; these differences serve him in lieu of colour. That is the reason why collisions do not daily occur on railways and at sea from mistakes made by colour-blind officials."

When the conditions are unfavourable for the colour-blind person supplementing his deficiency of sight by other means, as in rain, mist, and some other states of the atmosphere, the danger of making mistakes in the colours of signals becomes very great.

From the statistics quoted above, we cannot escape the conclusion that there are on board of our steamships and on our railways numerous instances of persons whose visual deficiencies disqualify them for their important responsibilities in regard to human life, for the tests hitherto

employed are nearly useless, perhaps even mischievous as leading to a false sense of security.

Without contending that all the requirements are thoroughly worked out, I am convinced that the systematic testing recommended by the International Medical Congress of last year (and copies of the "resolutions" have no doubt before now been widely distributed over the civilised world) would, if carried out as directed, at once reduce to a small fraction the dangers to travellers through mistakes from visual defects of officials on steamships and railways.